DOUGLAS-FIR BEETLE

Dendroctonus pseudotsugae Hopkins

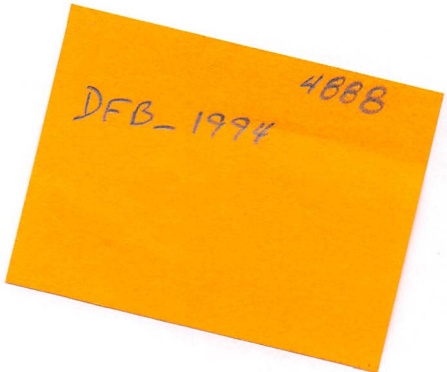
Douglas-fir beetle is the most destructive bark beetle attacking Douglas-fir in the Northern Region. Outbreaks develop in host trees following stand disturbances such as windthrow, fire, drought, or severe defoliation. Stands with extensive amounts of root disease may also predispose trees to beetle attack. Epidemics, though usually short-lived, may devastate susceptible stands before subsiding.

Hosts: Douglas-fir. Western larch may occasionally be attacked, but successful brood development has only been recorded in downed trees.

Damage: Beetles are attracted to slash, stumps, windthrow, and trees weakened by fire, drought, defoliation or disease. Populations expand rapidly in such material and in subsequent generations beetles attack and kill surrounding green trees. Douglas-fir beetles are not, however, particularly aggressive beetles. As more of the susceptible hosts are killed, and attacking beetles are forced into increasingly-healthier trees, populations decline. In sub-outbreak populations, mortality is confined to individual trees or small groups. During outbreaks, groups of dead trees may total 100 or more and yearly mortality may extend into the millions of board feet.

Life History: Douglas-fir beetle has one generation each year. Overwintering takes place beneath the bark of the tree in which they developed and occurs mainly as adults. A small percentage may overwinter as larvae. Spring emergence of adult beetles varies with location and weather, but usually occurs from mid-April to early June. Beetles that have passed the winter as larvae complete their development in spring and early summer. Those emerge and attack host trees in mid-summer. In addition, a few adults which made initial attacks in the spring may re-emerge to make a second attack in mid- to late summer. This "second flight" (in some years nearly a "continual flight") usually accounts for less than ten percent of the yearly total of attacked trees. Often, these later attacks fill in trees which were attacked during the initial spring flight. Broods require one year to complete their development--beetles emerging in spring are from the previous spring's brood and beetles flying later in the summer are typically from summer broods.

Identification: Evidence that a tree has been successfully attacked is usually the reddish-brown boring dust found in bark crevices on the lower portion of the tree's bole or on the ground at its base. Wind and rain may remove the dust, however, and since attacks are often high on the bole, careful inspection may be required to determine if beetles are present. An occasionally evident sign of infestation may be clear resin which has exuded from the upper level of attacks--typically 30 to 35 feet off the ground. These "pitch streamers" are often visible for a considerable distance. Streams of pitch lower on the bole may be evidence of unsuccessful attacks or other injury. As a rule, successful attacks can only be confirmed by removing sections of bark to reveal egg galleries, eggs, and/or developing brood.



Distinctive egg galleries are constructed beneath the bark by female beetles as they bore upward through the phloem. Galleries are parallel to wood grain and are commonly 8 to 10 inches in length; usually longer in downed logs. Eggs are laid, in nitches, alternately along opposite sides of galleries. After hatching, larvae mine outward from, and perpendicular to, the egg gallery as they feed in the phloem.

When the larvae have completed their development, they construct pupal cells at the ends of their feeding galleries. Pupal cells may be well within the bark. Larvae are white, legless grubs; pupae white to cream-colored. Immature beetles are light brown, becoming dark brown to black, with reddish wing covers, as they mature. Older beetles may be totally black.

Several months after a tree has been attacked, its foliage begins to discolor. Needles first turn yellow, then orange, and finally a reddish brown. Discoloration rate varies with local conditions and individual trees. During dry years, trees fade more quickly--occasionally becoming yellowish-green to orange later the same year they are attacked. Typically, trees begin to fade the year following attack. Tree-to-tree fading also varies with resistance to the staining fungi introduced by the beetles.

MANAGEMENT ALTERNATIVES

Salvage of Windthrow

Douglas-fir outbreaks are typically initiated by some type of stand disturbance--the most common being windthrow, snow breakage or other weather-related phenomena. Downed trees, logs, or other large-diameter debris are very attractive to Douglas-fir beetles. Beetles attracted to such material are capable of building high populations in a short period of time. New generations emerge and attack susceptible green trees in the surrounding stand. Once an outbreak has started, it normally lasts about three years in an area. Peak attack typically occurs the second year. If other weakening factors, such as defoliation, drought, fire, or root disease are present, the beetle outbreak may be prolonged for several years.

Timely salvage of down, damaged, or severely weakened Douglas-fir is a primary means of preventing beetle outbreaks. Such activity must be accomplished either before beetles attack it initially, or before they emerge the following spring. Beetle-infested material, hauled from the woods, must be processed prior to beetle flight to prevent new outbreaks from being initiated near mill sites.

Trap Trees

Because Douglas-fir beetles prefer freshly-downed trees to standing ones, a trap-tree program can be useful in suppressing beetle populations. The use of trap trees has become a standard practice that can be used whenever beetle populations are present or suspected. Trap trees can be ones either cut prior to beetle flight, or standing, green trees to which pheromone tree baits have been attached. The latter have the advantage of not having to be cut before beetle flight. Either technique will contain beetles in the treated area.

Trap trees can be dropped in late fall, if done sufficiently late they don't dry significantly before spring. Tree baits are best applied in the spring, prior to adult emergence. Attacking beetles are so effectively attracted to baited or felled trees, that standing green trees in the area, except for a few immediately adjacent to down or baited trees, are rarely attacked. Trap trees must be removed as soon as practicable following beetle flight to be effective. Should either technique be used, and infested trees not subsequently removed, the beetle outbreak likely would be exacerbated.

If felled trees are used, they should be cut in groups of 3 to 5 trees. Diameters should be 15 inches or larger. Ideally, the largest, green trees in the stand should be chosen. Trees should be dropped in the shade, and left unlimbed and unbucked. Trees left in the sun, or where a major portion of the bole receives direct sunlight, do not attract beetles nearly as well as those in a shaded environment. Trees could be cut in late fall; but preferably early spring, before April 1. They should be left until about mid-July, if possible. The sooner trees are removed, after beetle flight, the better. Certainly they need to be removed before the following April 1.

Trees selected for baiting should also be among the largest--preferably in dense, shaded parts of the stand. They too, should be baited prior to April 1, left in place until after beetle flight, then removed as soon as possible.

Timing of Harvest

An adjunct to a trap tree program is the judicious timing of harvests to take advantage of the beetles' natural attraction to downed trees. Trees dropped in early spring, prior to about April 1, and left through beetle flight, can attract and hold beetles to the site being harvested. This technique can effectively prevent any beetles in the area from dispersing to other sites. Again, infested trees must be removed before subsequent beetle emergence.

Population Manipulation Using Pheromones

When harvesting is being contemplated in Douglas-fir stands, pheromone tree baits can be used to stimulate attacks of trees in a specific stand that is scheduled for removal (Gibson and Oakes 1991). This technique is equally effective as a population reduction measure (see above), or as a preventive measure to help remove or "mop-up" residual populations. This can be very effective in maintaining low beetle populations in areas to be harvested, or in areas adjacent to these disturbed sites. Attractant tree baits can be used in small clearcuts, along rights-of-way, or in any other situation where beetle populations exist or threaten trees and the baited trees are certain to be removed following their attack. Tree baits are sufficiently effective that almost always there is "spill over" into adjacent, unbaited trees. Not only should harvest plans include those trees, but care should be exercised in the use of baits to make sure that beetles do not attack selected leave trees.

Another strategy, proven effective in preventing attacks in windthrown trees, takes advantage of an anti-attractant pheromone, also produced by the beetle. The beetle produces this pheromone--methylcyclohexanone (MCH)--as a means of protecting developing broods from overpopulation in a single tree. Synthetic

formulations, aerially applied, have effectively prevented attacks in downed material until it could either be salvaged, or became unattractive as a brood site (McGregor, et al, 1984). When windthrow cannot be timely salvaged, the application of MCH will prevent its colonization by beetles and forestall population increases which could ultimately threaten adjacent green stands. Though some testing has been done, it has not yet been proven to be equally effective in protecting standing, green trees. EPA registration for the use of MCH as a preventive strategy is pending.

Silvicultural Manipulations

Hazard Rating: A comprehensive hazard rating system for Douglas-fir beetle in susceptible Douglas-fir stands is being developed. Presently, stand susceptibility is based on characteristics associated with past outbreaks. Furniss, and others (1979), stated stand susceptibility is positively correlated with the proportion of Douglas-fir in the stand, its density, and its age.

Furniss, and others (1981), identified individual tree susceptibility characteristics as well as those factors which seem to delimit susceptible stands. Trees on which attacks are more dense and successful are those which are older, larger, more dominant, and more productive of attractant resins. Stand characteristics linked with susceptibility are:

1. Density. Density-related factors reflect the importance of moisture stress and shaded-stem environment. The denser the stand, the higher the susceptibility to beetle attack. Data suggest stands at 80 to 120 percent of normal stocking are most vulnerable.

2. Species Diversity and Habitat Type. No definitive correlation between habitat type and beetle-caused mortality has been developed; however, mortality is usually greatest on the more moist habitat types where Douglas-fir grows most productively. Warm, dry sites may produce susceptible stands unless they are so harsh that tree growth is sparse and slow. Little mortality has been observed on most of the subalpine fir types in which Douglas-fir is seral.

3. Stand Age. Average age of most Douglas-fir killed exceeds 120 years. In outbreaks and in more densely-stocked stands, younger trees may be killed.

4. Disease. Most agree there is a relationship between root-diseased Douglas-fir and endemic populations of beetles. That relationship is not as pronounced during outbreaks. The presence of root disease in mature trees likely contributes to their susceptibility to beetle attack by exacerbating the effects of moisture stress.

5. Injury. Injuries--such as fire, wind and snow breakage, defoliation, winter desiccation, and/or frost damage--are believed to predispose trees or stands to beetle attack. Any factor(s) which substantially reduce tree vigor will render them more susceptible to beetle depredation.

Resistance to population expansion, or outbreak initiation, is increased as (1) susceptible trees are killed by beetles, (2) stand density is reduced through logging, (3) or environmental stress is reduced through improved moisture/weather conditions. As infested-group size declines, and a higher proportion of attacked trees survive, natural enemies of the beetle play a bigger role in population reduction. Populations are then maintained at endemic levels through host resistance and natural enemies until conditions conducive to population buildup occurs once again.

We can do much to reduce the likelihood of epidemics by maintaining vigorous stand conditions and timely salvage of the products of stand disturbances. A necessary first step in the prevention of beetle outbreaks is the identification of stands most likely to support an epidemic--hence, the value of a hazard-rating system. While a more comprehensive system is being evaluated, one developed by Weatherby and Thier (1993) has found utility in parts of the intermountain West. Based largely on the observations of Furniss, and others (1981); but on other published and observed data as well, their hazard-rating system enumerates the following "high hazard" conditions for Douglas-fir stands:

Stand density: Stocking greater than 250 square feet basal area,
Percent Douglas-fir in stand: Greater than 50 percent,
Average stand age: Greater than 120 years,
Average diameter Douglas-fir sawtimber: Greater than 14 inches.

Outbreak prevention is best accomplished by reducing hazard associated with one or more of these conditions through some type of stand manipulation. Alternatives include commercial thinnings, or any of the several regenerative methods, which will help meet stand and site resource objectives. Any method which will ultimately reduce stocking, percent of beetle host, average stand age or size, will produce stand conditions less favorable to Douglas-fir beetles.

In summary, preventive management is the most effective and economical method of reducing mortality attributable to the beetle. And the identification of susceptible stands and the reduction of that susceptibility prior to some type of stand disturbance is the best preventive technique. A management system for Douglas-fir was developed for stands in British Columbia (Lejeune 1961). It is equally applicable to our Region. It includes the following features:

1. Prevention. Judicious timing of logging and prompt removal/disposal of logs, large slash and cull material will eliminate potential brood sites for the beetle. Preventive measures include the identification and treatment of high-hazard stands. Anti-attractant pheromone use has been added to these strategies.

2. Remedial. Should outbreaks occur, remedial measures such as the use of trap trees may be warranted. The use of pheromone tree baits is also an effective remedial tool.

3. Brood destruction. Treatment of infested material--slash, cull logs, etc.--through piling and burning or peeling may be warranted if other utilization opportunities are not available.

Natural Control

According to Furniss and Orr (1978), resistance of live trees is the most important natural factor controlling Douglas-fir beetle populations. Trees sustaining physical damage, or ones stressed by drought, defoliation, or disease are most susceptible to beetle attack and the furtherance of an outbreak. By keeping stands in a vigorous condition and removing susceptible trees or downed material, managers can most benefit from this natural resistance factor.

Climate and weather also influence beetle populations. Extremely cold, dry winters would have a detrimental effect on overwintering broods. At the other extreme, droughty conditions stress host trees and favor population buildups.

Naturally occurring parasites and predators play a role in population reduction during non-outbreak conditions, but apparently are not important regulating factors when populations become abnormally high. The most important insect parasite is a Braconid wasp which parasitizes the beetle's larval stage. Predators include Dolicopdid flies, the larvae of which prey upon beetle larvae; and Clerid beetles which are predaceous on both the larval and adult stages. Woodpeckers feed on developing larvae higher on the tree bole, where bark is thinner; but their overall effect is probably minimal.

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Photo Captions

A. Adult Dendroctonus pseudotsugae in egg galleries (USFS, INT)

B. Gallery pattern (USFS, INT)

C. Larvae (USFS, INT)

D. Pupae (USFS, INT)